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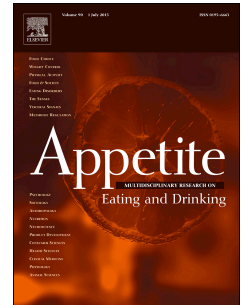
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# Accepted Manuscript

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## **Efficacy of the Attention Control Program on Reducing Attentional Bias in Obese and Overweight Dieters**

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### **Abstract**

Evidence indicates that attentional bias and dieter's eating styles (i.e., external, emotional, restraint) play important roles in the success or failure of dieters. *First*, we studied food-related attentional bias (FAB; based on interference scores on a modified Stroop test), eating styles (Dutch Eating Behavior Questionnaire), and increases in body mass index (BMI) in overweight or obese dieters ( $n = 34$ ) and nondieters ( $n = 35$ ). Compared with nondieters, dieters showed higher FAB, which was positively associated with BMI. In addition, the majority of overweight and obese participants had higher scores on emotional and restrained eating styles. *Second*, we investigated the effect of a Food Attention Control Training Program (Food-ACTP) on reducing FAB and dieting success. Dieters ( $n = 49$ ) were divided into three groups: intervention (training), no-intervention (control), and sham-intervention, all of whom were measured at pretest, posttest, and follow up. Only the intervention group showed reductions in their FAB, diet failure rate, and BMI at follow up. For the intervention group, there was a significant interaction between changes in FAB and eating styles in predicting decreases in BMI. Overall, this work shows that attentional bias plays an important role in eating behavior, and dieters can benefit from practicing with Food-ACTP as a complimentary intervention. The exact mechanism through which Food-ACTP improves dieting success awaits further investigation.

**Keywords:** attentional bias, emotional Stroop test, cognitive bias modification-attention (CBM-A), eating styles, dieting, obesity treatment

## **Efficacy of the Attention Control Program on Reducing Attentional Bias in Obese and Overweight Dieters**

Limiting calorie intake by dieting is the most common approach to treating obesity. However, evidence suggests that in spite of their desire, most dieters are not able to maintain their diet, and ultimately re-gain any lost weight (e.g., Papies, Stroebe, & Aarts, 2008; Werrij et al., 2009). Repeated failures in reaching a desired weight, as well as obesity itself, can lead to intense concerns about one's body, depressed mood, and reduced self-esteem (Werrij et al., 2009).

Both health specialists and obese people testify that in order to achieve a normal weight it is necessary to change life style; this means more exercise and greater adherence to diet including avoidance of high calorie food (Jansen, Houben, & Roefs, 2015). However, the intention per se is not enough as many dieters cannot resist their temptation for eating, and as studies show (e.g. Mann et al., 2007), some even put on additional weight perhaps reflecting a craving for food that overshadows the desire for achieving a normal weight.

One reason underling overeating is that obese and overweight individuals may have difficulty in ignoring stimuli that are related to eating and the desire to eat, i.e., a cognitive bias, which makes it hard to resist their craving for food (Roefs, Werthmann, Houben, Hofmann, & Nordgren, 2015). In an environment rich in food-related stimuli, such a bias would promote excessive calorie intake (Werthmann, Jansen, & Roefs, 2015). One of the cognitive components involved in eating is *attention*, though evidence for food-related attentional biases (FAB) is inconsistent (Roefs et al., 2015; Werthmann et al., 2015). Where there is evidence in support of the role of FAB in obesity/overweight (Braet & Crombez, 2003; Castellanos et al., 2009; Gearhardt, Treat, Hollingworth, & Corbin, 2012; Yokum, Ng, & Stice, 2011), restrained eating (Green & Rogers, 1993; Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010; Overduin, Jansen, & Louwerse, 1995)

and dieting (Nijs, Muris, Euser, & Franken, 2010), other studies suggest that FAB among restrained eaters (Werthmann et al., 2013) and dieters (Dobson & Dozois, 2004; Tapper, Pothos, Fadardi, & Ziori, 2008) was not different from that of people with normal weight and control participants. In Nijs et al.'s (2010) study, obese and overweight participants showed FAB only when hungry, and yet, in another study (Graham, Hoover, Ceballos, & Komogortsev, 2011) this group's FAB was less than that of participants with normal weight. Therefore, it is still premature to conclude the precise role of attentional bias in obesity (Doolan, Breslin, Hanna, & Gallagher, 2015). Nevertheless, the inconsistency in findings about the role of FAB could be due a disparity in measures of attentional bias which target different underlying processes (Nijs et al., 2010). One frequently used measure of FAB is the food-Stroop test, which calculates a difference score based on the respondents' reaction times to food-related vs. food-unrelated stimuli (Roefs et al., 2015). Although some believe that Stroop's interference score is not an appropriate measure of attentional bias (Matt Field & Christiansen, 2012), others believe that there is sufficient evidence in support of the test's reliability and validity (e.g., Fadardi & Ziaee, 2010b).

Moreover, Brooks, Prince, Stahl, Campbell, and Treasure (2011) reviewed studies using various paradigms of measuring attentional bias, memory, and judgment bias in people with eating disorder and restrain eating. Compared to others, the food-Stroop test yielded a sufficient number of studies for meta-analysis with effect sizes varying from small to medium. Therefore, it seems that the food-Stroop test can be reliably used to measure food attentional biases.

Calitri, Pothos, Tapper, Brunstrom, and Rogers (2010) studied the predictive value of cognitive biases to food cues (assessed by emotional Stroop and dot probe tasks) on weight change over a 1-year period. No effects of cognitive bias were found with the dot probe task. However, for the emotional Stroop, cognitive bias to unhealthy foods predicted an increase in BMI whereas

cognitive bias to healthy foods was associated with a decrease in BMI. Fadardi and Bazzaz (2011) compared attentional bias to healthy and unhealthy food pictures that were presented subliminally using a combi-Stroop test. They concluded that dieters showed significantly higher food attentional bias than nondieters do.

More generally, the underlying causes for overeating likely vary among people (Strien, 2002). For example, one might respond to his/her negative emotions by overeating (emotional eating) while another person might overeat in response to signs of food, e.g., the sight or smell of food (external eating). Yet a third person might be constantly concerned about weight loss but he/she may not always be successful in doing so (restrained eating). Thus, the person may alternate between periods of overeating and dieting. These types of eating behavior have been viewed through psychosomatic, externality, and restraint theories. Herman and Polivy (1980) stated that an individual's eating style is a function of two opposing forces; one persuading the person to eat and another one *restraining* him/her from eating. Therefore, a boundary between feeling hungry and satisfied emerges, which is separated by a grey area called *biological indifference*. The fluctuation of the area is largely determined by psychological factors and one's decisions on the amount of food to be ingested. To conclude, each of the eating styles has its own etiology and treatment, and to achieve long-lasting results, a person's dieting program should be consistent with his/her eating behavior (Strien, 2002).

Evidence on the relationship between attentional bias and eating styles is inconsistent (Werthmann et al., 2015). Some studies suggest that high scores on a restrained eating scale are accompanied by higher attentional bias for food-related stimuli (e.g., Hollitt et al., 2010; Overduin et al., 1995; Tapper et al., 2008) and self-reported weight fluctuations (e.g., Meule, Vögele, & Kübler, 2012), whereas, other studies (e.g., Jansen, Huygens, & Tenney, 1998; Werthmann et al., 2013)

suggest that restrained eating is not accompanied by attentional bias for food-related stimuli. Pothos, Tapper, Fadardi, and Ziori (2006) found that high scores on external and restrained eating scales were associated with high attentional bias for food-related stimuli (see also Hepworth, Mogg, Brignell, & Bradley, 2010). Hou et al. (2011) concluded that attentional bias for food cues correlated positively with external eating and trait impulsivity. Based on the above analysis the first study in this paper explored the relationship between BMI, eating style and FAB in dieters and nondieters. In addition, eating behaviors vary among various cultures. This poses the question of whether cultural differences have any impact on eating behaviors in dieters. The majority of previous studies were conducted in Western settings hence studies that explore attentional bias and eating behaviors among dieters and nondieters from Eastern cultures could shed light on relevant cultural differences.

The current study sought to test the relevance of attentional bias in weight management among a sample of Iranian dieters. Therefore, this study tested the following hypotheses (a) There is a significant difference between dieters and nondieters on BMI, food-related interference scores (but not classic Stroop and life goal-related interference scores), and eating styles scores; (b) BMI can be predicted based on the participants' attentional bias for food-related stimuli, even after controlling for their eating styles scores; and (c) There are significant interaction terms between food interference and eating styles scores.

## Study One

### Method

**Participants.** The sample included dieters and nondieters. All participants volunteered to participate in the experiment. Dieters (34 females,  $M_{\text{age}} = 34.4$  years, age range: 18-40 years) were

recruited via advertisement in a diet center in Mashhad, Iran. The advert announced the study as one related to eating, which required completing a few questionnaires and responding to a series of stimuli that appeared on a computer screen. Nondieters (12 males, 23 females,  $M_{\text{age}} = 21.9$  years, age range: 18-25 years) were students at Ferdowsi University of Mashhad. The study advert was put on the university's website to reach a wider population of students. The advert asked for participants who were not suffering from eating problems, were not overweight, and had never been on a diet program to lose or gain weight.

Additional criteria by which the participants were recruited included the following: the participants were able to use a computer; were between 18 to 40 years old; and were able to respond correctly to more than 70% of the stimuli (colored patches) in the practice phase. Excluding criteria included suffering from color blindness, a physical disability or any forms of psychological disorders (including, anorexia nervosa and bulimia nervosa). All the participants were native Persian speakers.

### **Materials and Procedure**

**The Dutch Eating Behavior Questionnaire (DEBQ).** This questionnaire contains 33 questions and three subscales to evaluate external (10 questions), emotional (13 questions), and restrained eating behaviors (10 questions) (Van Strien, Frijters, Bergers, & Defares, 1986). The participants were asked to determine how much each question represented their eating behavior and to mark their choice accordingly. The questionnaire has a Cronbach's alpha of  $\alpha = 0.82$ -to- $0.93$  for its subscales (Jahnke & Warschburger, 2008). The Persian version of the questionnaire was translated back into English and approved by Boom Test Uitgevers, (Amsterdam, The Netherlands).

**The modified Stroop test.** The test comprised four categories of stimuli: food-related words were used from another cross-cultural study (Tapper et al., 2008) (e.g., pizza, pastries, French fries,



jam, chocolate, ice cream, beans, and bread); life goal-related words (e.g., marriage); control words (e.g., window); and classic Stroop color words. In the last category, half of the words were presented in congruent colors (e.g., *red* in red color) and the others were presented in incongruent colors (e.g., *blue* in red color). In total, 128 words were presented individually in a randomized order, each appearing in one of four colors: red, blue, green, or yellow (each category contained eight different words and each word was presented in all four colors). Food-related, goal-related, and control words were matched for length, number of syllables, and whether they were nouns or adjectives. Because there was no corpus for frequency of words in Persian, the authors relied on their own knowledge as native speakers of the language, avoiding highly familiar or apparently unfamiliar words to include in the list of stimuli. To ensure relevance, words which had been previously ranked more relevant to each category by another sample of participants, were selected to be used in the task.

For completing the Stroop test, participants were instructed to press keys relevant to the color of the words that were displayed on the screen as accurately and quickly as possible, while ignoring the meaning of the words displayed. The interval between the stimuli was a fixation cross "+" that was displayed for 500 ms. Each word disappeared after pressing a key or the elapsed time of 3000 ms. The software recorded the participants' response time (RT) in milliseconds and the number of correct, incorrect, and no responses.

**Apparatus.** SuperLab Pro SDK (Cedrus-Corporation, 1999) was used to run the computerized Stroop test. All stimuli were presented via a PC on a 15" computer screen that was located about 40cm away from the participant's eyes. The input device was a standard keyboard with four of its keys marked with color stickers ("Z" for blue, "C" for green, "<" for yellow and "?" for red).

## Procedure

The task was introduced as an experiment to measure the participant's reaction times to a series of stimuli. After obtaining the formal consent of all the participants, they were asked about food deprivation by asking two questions: Are you feeling hungry severely? And when did you eat your last meal? None of the participants reported severe hunger, and the maximum reported time from their last meal was three hours.

Prior to the Stroop test, participants completed a practice task which comprised of responding to 70 color patches (red, yellow, green or blue with equal frequency) by pressing the correct color key. The participants were then given feedback in the practice task. In return as feedback, the correct key was followed by the "+" sign, the incorrect key was followed by the word "False", and a delay was followed by the word "late." The size and the presentation time-limit of the color patches were matched with the Stroop test's stimuli. After the completion of the Stroop test, the participants were asked to complete the DEBQ, and then their height and weight were recorded.

## Results

Incorrect and no-response trials were considered as errors and RTs less than 500 ms or more than 2500 ms were designated as outlier responses and were excluded from the subsequent analyses. A total of 7.14 % of the dieters' RTs and 9.15 % of the nondieters' RTs on the Stroop test were excluded.

Because the number of errors in each category of words can be inferred as heightened attention to processing the semantic content of that category of words (e.g., van Holst et al., 2012), a MANOVA was conducted to compare dieters and nondieters' error responses. Results revealed that, compared to dieters, nondieters' made more errors only on food related (Mean = 946.76;  $SD = 313.23$  vs. Mean = 866.66;  $SD = 213.87$ , respectively;  $F(1, 67) = 198.73$ ,  $p < 0.001$ ) and goal-

related (Mean = 949.42;  $SD = 316.27$  vs. Mean = 878.05;  $SD = 203.211$ , respectively;  $F(1, 67) = 4.78, p = 0.032$ ) word categories. A correlational analysis showed that nondieters' number of errors was positively related to the speed of responding to the food-related ( $r_{(35)} = .35; p = .019$ ) and goal-related stimuli ( $r_{(35)} = .44; p = .004$ ). The correlation between the number of errors and their counterpart RTs were not significant for dieters.

The classic Stroop interference score for each participant was calculated by subtracting the mean RT to the congruent color words from the mean RT to the incongruent color words. The score has been considered as an index of participants' cognitive flexibility and inhibitory ability in previous studies (e.g., Fadardi, Ziaee, & Shamloo, 2009; Fadardi & Ziaee, 2010a). To calculate food interference scores, the mean RTs to the control words were subtracted from the mean RTs to the food-related words for each individual participant. Life goals interference scores were calculated as a nonfood-related emotional index by subtracting the participants' mean RTs to the goal-related words from their mean RTs to the control words.

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Table 1 about here  
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To test differences between the two groups on measures of attentional bias and eating styles scores, a multivariate analysis of variance (MANOVA) was conducted with group as the fixed factor and seven dependent variables as shown in Table 1. There was a significant main effect for group in the model,  $F(7, 60) = 22.33, p < 0.001, \eta^2 = 0.71; d = 3.12$  (the  $F$  value is Wilks' lambda). The results indicated that, compared with non-dieters, dieters had a greater food attentional bias, higher scores on restrained eating, and higher scores on emotional eating scales (but not in external eating) (see Table 1).

It is worthwhile noting that all participants in the dieters group were female, whilst the nondieters group comprised a mixture of males and females. Because one group comprised one gender only, it was not possible to enter gender as an additional factor into the MANOVA model and then calculate its interaction term with group. Therefore, to test whether gender could have affected interference scores, BMI, and eating styles among the nondieters, we ran a series of independent *t*-tests between males and females of the nondieters group, and we found no significant difference on any of the variables ( $p > .05$ ). Moreover, we restricted our MANOVA model (Table 1) to females only, and again, we found exactly the same results, i.e., significant difference across the two groups on food-interference ( $F(1, 54) = 6.26; p = .015, \eta^2 = .10$ ); BMI ( $F(1, 54) = 79.84; p < .001, \eta^2 = .59$ ); emotional eating ( $F(1, 54) = 8.73; p = .005, \eta^2 = .13$ ); and restrained eating ( $F(1, 54) = 21.09; p < .001, \eta^2 = .28$ ). Therefore, it seems unlikely that the observed group differences were significantly influenced by the distribution of gender across the two samples. Similarly, for all participants, age was not correlated with any interference scores ( $p > 0.5$ ).

Because BMI was different between the two groups, it was important to consider influencing factors on observed group differences on the FAB score. In an attempt to explore the effects of BMI and dieting condition, we split dieters into two groups based on their median BMI score (i.e., 30.15) and compared them on their food-interference score. The result of the independent *t*-test was not significant,  $t(32) = .18; p = .85$ ; therefore, it seems that attentional bias was affected by the participants' dieting status rather than simply by their BMI scores.

To test the hypothesis whether BMI can be predicted based on the participants' food interference scores, after controlling for age, gender, and the eating styles scores, a hierarchical regression analysis was conducted in which age, gender, and eating styles scores were entered into the first step of the model, and food interference score was entered into the second step of the model.

In the correlation matrix, there was no significant correlation between FAB and either of the eating behavior score, but the correlation between FAB with BMI ( $r = 0.29$ ;  $p < .01$ ), and BMI with emotional eating ( $r = .54$ ;  $p < .01$ ), restrained eating ( $r = 0.42$ ;  $p < .01$ ) was significant. As shown in Table 2, in the regression model, age, emotional eating, and restrained eating were significant predictors of BMI at the first step. On the second step, there was a significant change in the variance for food interference score ( $F(6, 62) = 17.50$ ,  $p < 0.001$ ), after controlling for the variables at the first step. Moreover, we used z-scores to test for any interaction terms between eating styles and food interference. The only significant interaction term was for food interference  $\times$  restrained eating ( $F(3, 65) = 9.036$ ,  $p < 0.001$ ).

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Table 2 about here  
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### Discussion of Study 1 and Introduction to Study 2

In Study 1, we found that dieters demonstrated greater attentional bias to foods compared to nondieters. Furthermore, dieters' emotional and restrained eating style scores were significantly higher than nondieters'. Finally, attentional biases towards food play a significant role in weight gain particularly in those individuals with a restrained eating style. Given these results, in a second study we have explored whether cognitive training can aid dieting behavior by reducing attentional biases. Evidence on the role of attentional biases in eating behaviors (including emotional responses) has led many researchers to conclude that they can be altered through cognitive interventions (Hertel & Mathews, 2011); the approach has led to the development of various programs for cognitive bias modification (CBM). For example, Cox, Fadardi, Hosier, and Pothos (2015) reported that their attentional training has helped hazardous, harmful drinkers reduce their

alcohol-related attentional bias, and that they showed posttraining reductions in alcohol consumption and improvements on the other drinking-related indices. In reference to attentional bias for food and its reported similarities with other addictive behaviors (Ziauddeen & Fletcher, 2013), the results of CBM programs have been inconsistent. On one hand, Werthmann, Field, Roefs, Nederkoorn, and Jansen (2014) reported that participants who learnt to attend to chocolate consumed more chocolate and those who learnt to attend to other food stimuli consumed less chocolate. Moreover, Kemps, Tiggemann, Orr, and Grear (2013) showed that training participants to attend away from chocolate reduced their craving for and their actual consumption of chocolate. Furthermore, Kakoschke, Kemps, and Tiggemann (2014) showed that training attention towards healthy food resulted in the trainees increased consumption of healthy food. On the other hand, the results of some studies have failed to show a posttraining reduction in the trainees' hunger, food liking, saliva, craving, and actual food consumption (Boutelle, Kuckertz, Carlson, & Amir, 2014; Hardman, Rogers, Etchells, Houstoun, & Munafò, 2013). To conclude, and as Hertel and Mathews (2011) have also noted, although evidence on the clinical effectiveness of CBM is inconsistent, the theory-based CBM tradition is a useful approach in experimental studies addressing the relationships among cognitive processes, emotions, and behavior. The Food Attention Control Training Program (Food-ACTP) is a modified version of Alcohol Attention Control Training Program (Cox et al., 2015; Fadardi, 2003) and Drug Attention Control Training Program (Ziaee, Fadardi, Cox, & Yazdi, 2016). The main goal of the program is to help dieters to: (a) correct their automatic attention toward food-related stimuli; (b) decrease the time of disengagement of attention from high-calorie stimuli; and (c) enhance automatic cognitive processes to choose low-calorie stimuli (see materials and procedure below).

The second study tested whether a food-related attention training program could assist overweight and obese participants reduce their attentional bias for high calorie food and its impact

on diet-related improvement indices. For this second study, we tested the hypothesis that training with Food-ACTP will reduce food attentional bias and improve indices related to dieting success (i.e., maintain their dieting program, decreases in saliva secretion for high calorie food, and BMI).

## Study Two

### Method

**Participants.** The total sample size was calculated to be 54 participants based on: (a) the expected effect size from previous studies (e.g.,  $f^2 = .36$  in Fadardi & Cox (2009); (b) statistical method (repeated measures of MANOVA); (c) the number of groups ( $g = 3$ ); and (d) statistical power of 0.85 (Cohen, 1992). One participant from the intervention group; one participant from the no-intervention control group; and three participants from the sham-intervention group quit the study before the follow-up test. The final sample in the follow-up test comprised of 49 participants (3 males, 46 females,  $M_{\text{age}} = 30.02$  years, range: 18-40 years) (see Figure 1). The study was announced to the potential participants via advertisements in a diet center in Mashhad, Iran. Inclusion criteria were being between 18 and 40 years old, ability to use a computer, being on a diet to lose weight, being a native Persian speaker, and not participating in the first study or any similar studies. Through a preliminary interview, the participants were screened for the following exclusion criteria: suffering from color blindness, physical disability, or psychological disorder (especially anorexia nervosa and bulimia nervosa). They were allocated randomly to one of the intervention (training), sham intervention, or no-intervention control group. Participants who were allocated to the intervention and sham intervention groups were told that they would take part in four computerized training sessions.

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Figure 1 about here

## Materials and Procedure

**The modified Stroop test.** Attentional bias was measured by the same task which was used in the first study (see above).

**The Dutch Eating Behavior Questionnaire (DEBQ).** As with the first study, the Persian version of the DEBQ was used to measure the participants' scores in emotional, external, and restrained eating scales (see above).

**The Food Attention Control Training Program (Food-ACTP).** The task was adapted from *Alcohol Attention Control Training Program* (AACTP) that was used in the alcohol consumption study by Fadardi & Cox (2009). The trainees' favorite foods and beverages were used in the Food-ACTP to personalize stimuli for each participant. The images of high calorie (e.g., pizza) or low calorie (e.g., apple) foods or beverages were used as stimuli and were presented randomly on a computer screen. The Food-ACTP consisted of three series of stimuli that were presented from the easiest (Series 1) to the most difficult (Series 3). In the first series, images of the high calorie or low calorie foods or beverages were presented in a colored background (Figure 2). The second series comprised of images surrounded by a colored outline (Figure 3). Both the backgrounds and the outlines were in one of four colors, i.e., *red*, *yellow*, *blue*, or *green*. The instruction was to name the color of the background or the outline as accurately and quickly as possible, while ignoring the image of the food and the beverage. The color naming latency time (the elapsed time between the presentation of the stimulus and the participant's response), mean reaction times, number of errors, and the interference score (calculated by subtracting the mean RTs to low calorie stimuli from the mean RTs to high calorie stimuli) were recorded. At the end of each trial, the calculated indices were used to give feedback to the participants and to determine the speed of



the presentation of stimulus on the next practice. For the first and second series of stimuli, the goal for the trainee was defined as the reduction of reaction times, number of errors (i.e., fewer than 10%), and the interference scores.

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Figures 2-to-4 about here  
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In the third series, two stimuli from Series 2 (one high calorie, one low calorie image of food or beverage) were simultaneously presented on the screen (Figure 4). The Food-ACTP determined the location of each stimulus on the screen in a random order. The instruction was to name the outline color of the low calorie stimuli, while ignoring the high calorie one and with the objectives of having fewer than 10% errors and reducing the reaction time to under a second. On the third series, only the mean RTs and the number of errors were recorded and they were used to give contingent feedback.

In summary, the Food-ACTP was designed with increasing level of difficulty in which: (a) the order of presentation of the stimuli was set from the easiest (Series 1) to the most difficult (Series 3) category, and (b) the time limit was reduced as the trials went on, based on the participant's performance.

**The sham-intervention program.** In the Sham-intervention program, 72 food and beverage images that were used in the training program were presented via a computer screen in four blocks. Each block consisted of 18 images and the participants were asked to press the space bar key to view each one.

**Salivary assessment.** Although evidence about the relation between saliva secretion and food craving are equivocal (Nirenberg & Miller, 1982), in some previous studies saliva secretion

was used to measure the psychophysiological index of craving for food cues (e.g., Van Gucht et al., 2008). It is likely that psychophysiological measures, compared with self-report measures, are more sensitive for detecting craving because they are less vulnerable to conscious control (Baker & Brandon, 1990). The Strongin-Hinsie-Peck's method (SHP; Peck, 1959) was used for salivary assessment. The stimuli used were 36 images of high calorie foods and beverages and 36 neutral images (of furniture).

In the salivary assessment phase, the participants were asked to drink a little amount of water and after five minutes, they were instructed to place two dental cotton rolls between their lower gum and cheeks (on both sides of the mouth) and place another one under the tongue and they were told to look at the computer screen (Peck, 1959). There were two series of stimuli presented on the computer screen: images of high calorie foods and beverages and control images (of furniture). The presentation of each series of images lasted about one minute, during which participants were asked to watch them only (i.e., no task requirements). Next, they were asked to remove the dental cotton rolls and put them in a zip-lock plastic bag. Before presenting the second series of images, during a five minute interval, they were encouraged to speak in order to restore normal salivary flow. The content of the conversation was kept unrelated to the stimuli observed or to eating. The participants were given three new dental cotton rolls before presenting the second series of images on the computer screen. The sequence of the presentations was counterbalanced amongst the participants. However, the order was kept unchanged in the post and follow-up tests for each individual participant. The weight of the cotton rolls was measured by a digital scale with an accuracy of 0.1 grams prior to and after the presentations.

**The Hunger Scale.** We used a Persian version of Grand (1968) Hunger Scale to measure the level of participants hunger and their appetite for food. The measure questions the last time that a

person has had food and the next time that one expects to eat. It also has two visual analogue measures that ask about (a) the severity of their hunger (from 'not hunger at all' to 'extremely hungry'); and (b) how much they can eat from their favorite food if available (from 'none at all' to 'as much as I could get'). The scale has been used in many studies on eating behaviors (e.g., Tapper & Pothos, 2009), including at least one in an earlier study with Iranian participants (Tapper, Pothos, Fadardi, & Ziori, 2008).

### **Apparatus**

The Food-ACTP, the Stroop test, and the sham-intervention program were presented using SuperLab Pro (SKD) software for Windows (Cedrus-Corporation, 1999). All words used in the Stroop test were presented on a black background in the center of a 15" computer screen that was located about 40 cm away from the participant's eyes. A standard keyboard in which four of the keys, using color stickers, were marked *red*, *yellow*, *blue*, and *green*, was used as the input device. The participants' reaction times and errors (incorrect or delayed responses) were recorded by SuperLab Pro automatically. The Microsoft Office Excel program was used to create a template for calculating each participant's errors and mean RTs for each category of stimuli that were presented during the Stroop test and the Food-ACTP training. The Microsoft Office PowerPoint program was used to present the images in the salivary assessment.

### **Procedure**

The measurements were conducted in the following order: completing the hunger scale; performing the salivary assessment task; performing the Stroop test (colored patches); performing the modified Stroop test; and completing the DEBQ. Finally, the height and weight, the number of unsuccessful diet attempts, and the demographic information of the participants (age, gender, educational level, and occupation) were recorded.

The Food-ACTP was designed to be conducted in four sessions over a four-week time span (one session each week) for the intervention group. In the first session, each participant chose the most favorite high and low calorie stimuli out of 210 presented images (seven stimuli for each category). The chosen images were saved in the participant's profile and were used in the training phase. Table 3 shows the pattern of the tasks in each session, the type of each series of stimuli used in the training, and the number of practices within each session.

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Table 3 about here

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The participants were encouraged to achieve predefined progress goals. The criteria for this progress was defined to be reduction of the interference scores to zero or less (for the first two series of stimuli), making errors on fewer than 10% of the trials within each practice, and decreasing the mean RTs. These criteria were set to make the tasks meaningful and goal-directed for the participants and motivate them to actively take part in the program. The program was set to increase the speed of stimulus presentation by 15% if a participant's performance was successful in each practice. A participant could move on the next level of the program (i.e., from background to halos to the pairs) only if he or she could meet the success criteria while the stimuli presentation speed had reached one second or faster. At the end of each single practice, the trainee was given contingent feedback on his/her performance (i.e., the number of errors, RTs, and the interference score) via the computer screen. Moreover, at the end of each practice session, a graphical feedback was given to the participants. This feedback presented the mean RTs to the high and low calorie stimuli and the interference scores (as an index of high calorie stimuli attentional bias).

The participants in the sham-intervention group engaged in the sham-training program for four sessions (one session per week). Each session lasted 15-20 minutes (similar to Food-ACTP) and it required the participants to look at images of high and low calorie foods and beverages on a computer screen. Once each participant in the intervention and sham-intervention groups completed the task or four weeks passed after the pretest for participants in the no-intervention control group, then the hunger, saliva, attentional bias, and eating behavior style scores were measured again and the participant's weights were recorded (posttest). All the variables were measured once again (as a follow-up test) three months after the posttest. At the end, the participants were debriefed and thanked for taking part in the program. Those from the no-intervention control and sham-intervention groups were allowed to take part in the Food-ACTP if they wished to do so.

### Results

Results of a multivariate analysis of variance showed that there were no significant differences in *age* and *unsuccessful diet attempts* among intervention, sham-intervention, and no-intervention control groups. Moreover, the Kruskal-Wallis test showed no significant differences in education, occupation, and marital status among the groups.

Response times between 400ms and 2500ms were considered as valid. After filtering incorrect and outlier responses (3 standard deviations less or more than the mean) and non-responding trials (6.6 % of data), interference scores were calculated for each category of words in the modified Stroop test (see Table 4).

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Table 4 about here

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All the variables that are shown in Table 4 were analyzed using multivariate analyses of variance. The results showed that at the baseline, there were no significant differences in the variables among the groups ( $F < 2$ ).

To determine whether the Food-ACTP reduced food attentional bias, MANCOVA were conducted. Prior to conducting the statistical model testing the food attentional bias, we correlated the participants' hunger scores at each assessment point with their food interference scores. There was no significant relationship hence we did not enter hunger scores as covariate in the subsequent data analysis. Next, all interference scores in the post- and follow-up tests were entered into the model as dependent variables and the group was entered as the fixed factor. In order to control the pretest effect, the interference scores in the pretest were entered into the model as covariates. Results showed that the group had a significant effect only on the food interference score at follow-up,  $F(2, 43) = 4.19, p = 0.022, \eta^2 = 0.16; d = 0.87$ , but not at posttest,  $F(2, 43) = 1.53, p = 0.22$ . Tukey post-hoc pairwise comparisons revealed that only in follow-up test, the mean score of food interference was significantly lower for the intervention group than for the no-intervention group (*Mean difference* = - 53.68, *SD* = 22.27,  $p = 0.02$ ) and for the sham intervention group (*Mean difference* = - 57.35, *SD* = 22.47,  $p = 0.01$ ). There was no significant difference between no-intervention and sham intervention groups (*Mean difference* = - 3.67, *SD* = 23.014,  $p = 0.87$ ) (see Figure 5).

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Figure 5 about here  
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To determine whether the Food-ACTP affected salivation (as an index for craving), another MANCOVA was conducted; in the model salivation in post- and follow-up tests were entered as

dependent variables, the group as the fixed factor, and salivation in pretest was entered as a covariate. No significant effect was observed for the group.

BMI reduction was considered as an index for treatment success. To test the hypothesis that the Food-ACTP could help trainees' weight reduction, a multivariate analysis of variance was conducted. BMI change scores in posttest (i.e.,  $BMI_2 - BMI_1$ ) and follow-up ( $BMI_3 - BMI_1$ ) were entered into the model as dependent variables and the group as the fixed factor. The results showed that group had a significant effect on BMI change scores from the pretest to the follow-up ( $F(2, 46) = 5.75, p = 0.006, \eta^2 = 0.20; d = 1.00$ ), but not from pretest to post test ( $F(2, 46) = 2.1, p = 0.13, \eta^2 = 0.08$ ). Post-hoc pairwise comparisons revealed that from the pretest to the follow-up test, the intervention group had more BMI reduction than the no-intervention group (*Mean difference* = -1.09, *SD* = 0.46,  $p = 0.02$ ) and sham intervention group (*Mean difference* = -1.58, *SD* = 0.48,  $p = 0.002$ ).

To determine whether the Food-ACTP could help trainees maintain their diet, the number of participants who quit their diet from the pretest to the posttest and to the follow-up test was analyzed. There were no participants who reported diet quitting from the pretest to the posttest. Therefore, diet failure rates were calculated from the pretest to the posttest which was 11.76%, 29.41%, and 50% for the intervention, no-intervention control, and sham-intervention groups, respectively. A Friedman test was conducted for each group separately. The results showed that quitting diet between the pretest and the follow-up assessment was not significant for the intervention group,  $\chi^2(2, N=17) = 2; p = 0.36$ , whereas, it was significant for the no-intervention control group,  $\chi^2(2, N=17) = 8.40; p = 0.015$ , and the sham-intervention group,  $\chi^2(2, N=15) = 6.33; p = 0.042$ .

As a post-hoc analysis, to test whether changes in the FAB and eating style scores could predict changes in the intervention group's BMI at the posttest and follow-up assessments, a series of hierarchical regression analyses were conducted. In each regression model, BMI change score was entered into the model as the predicted variable. Next, at the first step, FAB change scores and each of the eating styles change scores were entered into the model, followed by their interaction term (i.e., FAB change  $\times$  eating style change) at the second step. For all models, none of the variables in the first step was significant; however, the interaction term, FAB change  $\times$  restrained eating score, at follow-up assessment led to a significant change in the variance of the model ( $\Delta R^2 = .29$ ;  $F(1, 16) = 2.19$ ;  $t = 2.33$ ,  $p = .033$ ).

In summary, food attentional bias and BMI decreased in the intervention group on the follow-up test and this group's diet failure rate was significantly less than the other two groups.

### Discussion

In the present work we first tested the relationship between food attentional bias (FAB), BMI, and eating styles among nonclinical, overweight and obese dieters and normal weight nondieters. Results indicated that dieters showed higher FAB than nondieters. Also, dieters' scores in emotional and restrained eating styles were significantly higher than nondieters' scores. Moreover, FAB was positively associated with BMI, even after controlling for eating styles scores. Finally, the significant interaction term for FAB  $\times$  restrained eating in predicting levels of BMI suggests that attentional biases play a significant role in BMI particularly in those individuals with a restrained eating style. Subsequently, in the second study, we tested the effectiveness of a modified version of Attention Control Training Program (Food-ACTP) in reducing FAB, and promoting dieting success among dieters with various eating styles. The dieters did not match the criteria for clinical eating disorders.



Considering the positive outcomes following the use of an attention control program for alcoholics (i.e., AACTP; Cox et al., 2015) and drug abusers (Ziaee et al., 2016) our second study used a modified version of the program to test its impact on reducing dieters' food attentional bias. We compared an intervention group, who received Food-ACTP, with a sham-intervention group, with a no-intervention control group. We found that only the Food-ACTP Intervention group showed reductions in their FAB, diet failure rate, and BMI at the follow-up assessment. The trainees with restrained eating behavior benefited most of their FAB training in terms of reductions in their BMI. As such, this work not only supports an important role for attentional biases in overweight and obesity, but also that attentional training can ameliorate these effects at both a cognitive and behavioral level.

Results of the first study supports previous work indicating the role of FAB in obesity/overweight (e.g., Braet & Crombez, 2003; Castellanos et al., 2009; Gearhardt et al., 2012; Fadardi & Bazzaz, 2011; Yokum et al., 2011), though not all find such an effect (e.g., Dobson & Dozois, 2004; Tapper et al., 2008). The discrepancy in the findings could be due to methodological differences, e.g., Tapper et al. (2008) used a card version of the food-Stroop test. Indeed, Dobson and Dozois's (2004) conclusion of the lack of relationship between dieting and FAB was also based on four prior studies, of which two used the card version of the test. Perhaps importantly in this study, the analysis of eating styles suggested that the relationship between FAB and weight is not simple but may be mediated by other factors. In our case, a restrained eating style was seen to be an important factor linking FAB and weight.

It is noteworthy that based on the current evidence, it is hard to infer whether FAB is due to appetitive or aversive qualities of the salient stimuli on the emotional Stroop test (Field & Cox, 2008; Werthmann et al., 2015). To test whether FAB on the Stroop test has an appetitive property

(i.e., incentive salience), we ran a simple correlation on the dieters' food interference scores and their salivation index (i.e., saliva secretion to food stimuli minus saliva secretion to neutral stimuli) at pretest assessment, and we found a positive relationship ( $r(49) = 0.25, p = 0.044$ ). The finding implies that the direction of attentional bias for food stimuli on the food-Stroop test had an appetitive nature not aversive.

In reference to the significant interaction of FAB and restrained eating behavior, some researchers suggest that implementing food limitations could exacerbate one's sensitivity for food stimuli (e.g., Boon, Vogelzang, & Jansen, 2000; Kemps & Tiggemann, 2009; Papies et al., 2008). Many who diet in order to lose weight impose cognitive and behavioral limitations and restrictions on themselves. One account for increased FAB in restraint dieters is that the restriction exacerbates one's preoccupation with food which may result in increases in their sensitivity for food-related stimuli, vis-à-vis, FAB. Therefore, dieting programs that rely on forbidding certain food, rather than limiting its consumption, could have adverse consequences for calorie consumption among people with restraint eating behavior. There is evidence (Walsh, Kuhn, Brass, Wenke, & Haggard, 2010) showing that volitional self-regulation of an otherwise wanted act is associated with increased brain activity. This supports other evidence stating that an active state of mind for self-regulation (will power) actually may lead to ego depletion (Inzlicht & Schmeichel, 2012), i.e., increasing the possibility of doing an unwanted behavior such as alcohol use (Christiansen, Cole, & Field, 2012) which might be accompanied with increases in one's distractibility for unwanted stimuli (Englert, Bertrams, Furley, & Oudejans, 2015).

The results of the first study showed that obese dieters mostly have higher scores in emotional eating scales than nondieters, whereas the results of most previous studies conducted in Western societies (e.g., Anschutz, Van Strien, Van De Ven, & Engels, 2009; Burton, Smit, & Lightowler, 2007) have showed that external eating scores were positively associated with craving and higher levels of energy intake, especially of fat intake. Cultural factors can help to explain the difference. For instance, Iranian obese individuals may use food as a way to change their mood and obtain enjoyment. In their informal conversations, many participants mentioned going to restaurants and eating high-calorie foods (e.g., fast food, ice cream, and chocolate bars) as their main recreational activity in their family. This was done to such an extent that when these individuals decided to refrain from going to these places, they were reproached by their family members for ruining a fun activity. Most of these individuals reported that when they faced a sense of failure, their first reaction (and usually their only reaction) was to overeat or eat such forbidden foods (high-calorie).

The results of the second study showed that *attention control training* can act as a cognitive bias modification (CBM) for dieters and can lower their food attentional bias in the long term. These results are somewhat different from similar studies conducted on alcoholics (Fadardi & Cox, 2009) and substance abusers (Barerfan, Fadardi, & Cox, 2013; Ziaee et al., 2016). In these two studies, the effect of intervention was seen as a decrease in attentional bias in the posttest. However, in the present study, a decrease in attentional bias was seen in the follow-up test. Aside from basic differences (physiological, psychological, and nutritional) between alcohol and food, one explanation is that it simply takes longer for attentional biases for food stimuli to become established and then expressed. Whilst food is a basic biological requirement, alcohol is foremost a high incentive reward, and so may be underlain by more rapid learning. Nevertheless, Hayes and

Schmidt (2016) and O'Hara, Campbell, and Schmidt (2015) propose a model that emphasizes neural overlaps between eating disorders and substance abuse. From a learning point of view, the formation of association between seeing a food stimulus and feeling pleasure after eating starts from birth. Moreover, based on learning theories the older a learned behavior is, the harder it becomes to alter or eliminate it (*old habits die hard!*). Thus, more practice is necessary to change it and it takes longer to witness the results of developing new skills. Hertel and Mathews (2011) have argued, CBM interventions teach the trainees the skill of inhibition by encouraging them to adopt more inhibitory control strategies when exposed to food-related stimuli. Our findings are also consistent with a previous study (i.e. Schmidt, Richey, Buckner, & Timpano, 2009) that showed clinical improvement after CBM in participants with social anxiety disorder enhanced at four month follow-up. Interestingly, attention control training also led to a decrease in the participants' diet failure rate. Those who were completed the program continued dieting more than those in the other two groups suggesting a more general effect on cognitive control processes.

Salivation was measured as a physiological indicator of the participants' craving for food, and as an indicator of the incentive salience of the FAB. Despite reductions in the interventions group's food attentional bias, and contrary to our expectation, their salivation responses to high calorie food did not reduce across the assessment. One explanation for the finding is that salivation is a conditioned parasympathetic response to food and it may take very long to relinquish the response in sight of food. However, cognitive inhibitory processes can be more readily responsive to training programs, leading to less attentional bias for food-related stimuli.

### **Limitations and Future Directions**

The current two studies predominantly involved female participants and so caution is required in generalizing the findings across both genders. Furthermore, we specifically focused on a

non-clinical sample and so our conclusions relate most directly to the healthy population reporting issues of overweight or obesity. A final restriction in our sample was the choice to test on dieters (as opposed to healthy overweight nondieters). This may have resulted in the significant relationship between restrained eating and FAB (by definition most dieters will be restraining behavior in some way). Further work is necessary to explore the scope and applicability of the current results.

In the second study, whilst we anticipated reduced attentional biases, we also predicted the intervention group would demonstrate better compliance with their diet. This highlights an important area for further investigation in disentangling the cognitive mechanisms (and their underlying neurobiology) that are restructured during attentional training, and the way in which they then impact behavior. In this case, the training may have improved inhibitory control which then generalized to diet compliance. However, there are other explanations beyond the scope of the current work.

### **Conclusion**

Healthy diet and weight management are complex and multifaceted. The current work focused on the role of cognition including attentional biases in contributing to overweight and obesity. Whilst only one aspect, the present studies suggests that attentional biases in dieters play a functional role in behavior including failure in maintaining diet, and in weight. Furthermore, dieters who took part in cognitive training (via the Food-ACPT) showed decreases in their attentional bias for high calorie food, and they were less likely to quit their diet compared, to those who practiced with a sham version of the program. This work contributes to the growing literature on cognitive processes underlying maladaptive aspects of health behaviors, as well as identifying a novel intervention that shows promise in helping individuals maintain diets and live healthier lives. The

Food-ACTP is short and inexpensive and can be implemented across the Internet. Its effectiveness in clinical groups and across broader populations remains to be seen.

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Table 1

*Means and standard deviations for interference scores, BMI, and eating behavior scales in dieters and nondieters and the results of the MANOVA model.*

Measures	Group				MANOVA		
	Dieters		Nondieters		Between-groups effects		
	Mean	SD	Mean	SD	$F(1,67)$	$\eta^2$	$d$
Food Interference	39.49	94.38	-18.54	63.702	9.009*	0.11	.703
Classic Stroop Interference	84.99	81.200	102.82	79.51	0.85	0.01	.22
Life goals Interference	27.75	99.97	4.400	95.05	0.98	0.01	.24
BMI	31.77	5.24	21.306	2.64	110.57**	0.62	2.55
Emotional Eating	3.09	0.96	2.38	0.58	13.506**	0.16	.87
External Eating	3.37	0.72	3.31	0.54	.13	0.002	.08
Restrained Eating	3.35	0.708	2.27	0.79	35.32**	0.34	1.43

\* $p < 0.05$ ; \*\* $p < 0.001$

Table 2

*Results of hierarchical regression analysis of variables predicting BMI.*

Steps	Variables	<i>B</i>	<i>SE B</i>	<i>t</i>	$\Delta R^2$	$\beta$
1	Age	0.44	0.07	5.602	0.604**	0.49**
	Gender	- 0.84	1.49	- 0.56		- 0.50
	Emotional Eating	2.79	0.705	3.95		0.36**
	External Eating	1.15	0.95	1.21		0.11
	Restrained Eating	1.66	0.67	2.48		0.23*
2	Food Interference	0.01	0.006	2.03	0.025*	0.16*
	Food Int. * Emotional Eating	.27	.76	.35	.001	.037
	Food Int. * External Eating	.13	.67	.19	.001	.023
	Food Int. * Restrained Eating	-2.27	1.075	-2.11	.049*	-.22

*Note:* Gender was coded as males = 0, females = 1; Food Int. = Food interference score;

\*  $p < 0.05$ ; \*\*  $p < 0.001$ .



Table 3

*The pattern of the tasks and the number of practices in each Food-ACTP session.*

Task	Type of Stimuli		
	Series 1	Series 2	Series 3
	(Colored background)	(Colored outline)	(Paired)
Session 1	6	-	-
Session 2	2	4	-
Session 3	1	2	3
Session 4	-	-	6

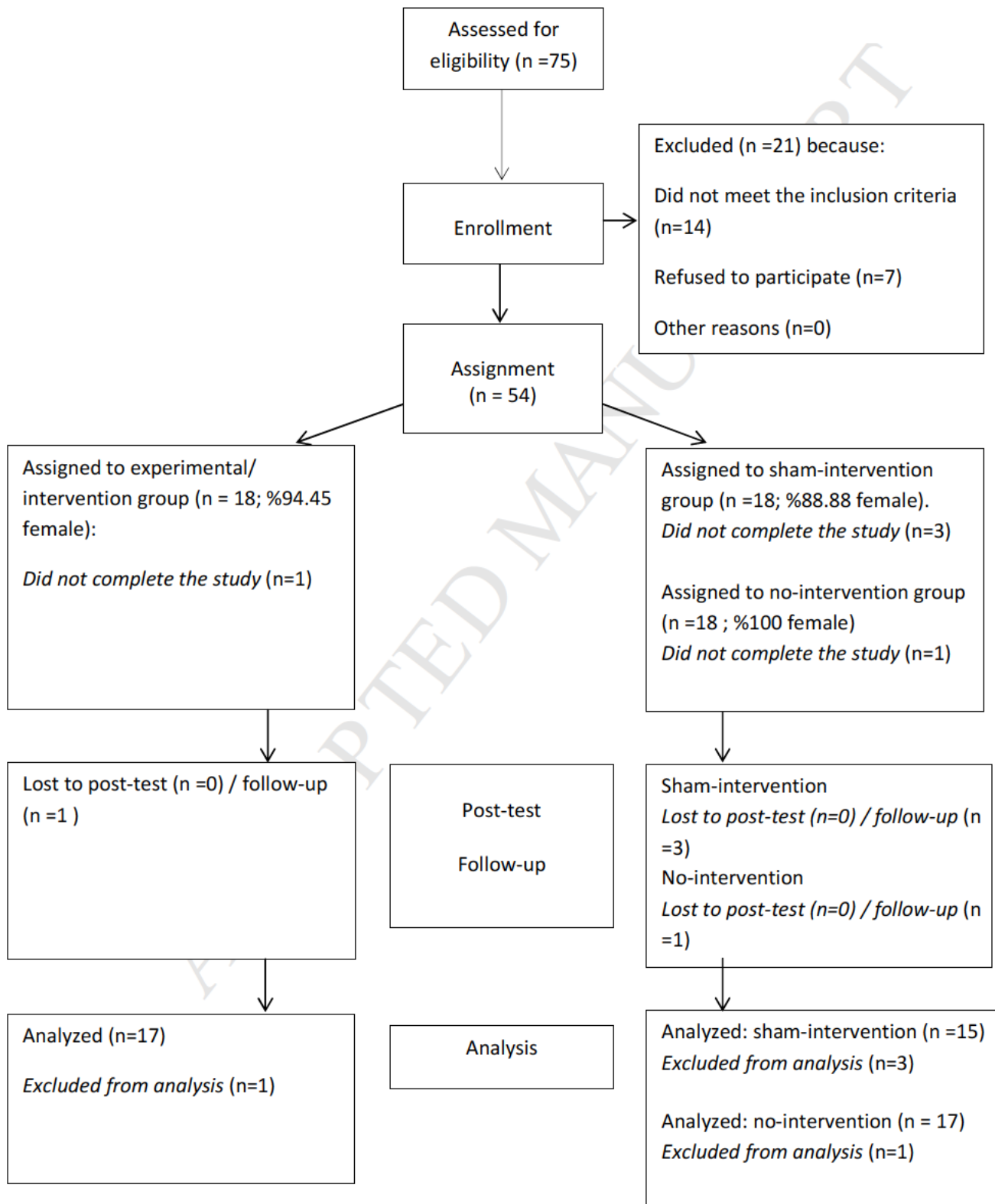
Table 4

*Means and standard deviations and comparisons of baseline measures across the study groups.*

	Experimental Group		Control Group		Sham-treatment Group		Group comparisons
Variable	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	MANOVA F (2, 46)
Emotional Eating	3.25	0.69	2.92	0.83	3.34	0.55	1.60 ( $p = .21$ )
External Eating	3.72	0.67	3.41	0.65	3.63	0.77	1.60 ( $p = .42$ )
Restrained Eating	3.18	0.71	3.20	0.38	3.03	0.83	1.60 ( $p = .72$ )
Classic Stroop Int.	103.92	116.56	144.51	95.39	112.26	120.36	1.60 ( $p = .56$ )
Food Interference	27.82	98.54	2.68	68.15	29.54	96.74	1.60 ( $p = .62$ )
Goal Interference	1.43	73.01	-28.34	67.58	6.30	69.79	1.60 ( $p = .32$ )
Hunger	2.71	2.31	2.06	2.33	1.67	1.50	1.60 ( $p = .83$ )
BMI	32.76	3.77	30.30	2.98	33.38	5.83	1.60 ( $p = .10$ )
Salivation (mg)	-0.16	0.44	-0.7	0.31	0.11	0.30	1.60 ( $p = .11$ )

*Note.* The classic Stroop interference scores (Classic Stroop Int.) were calculated by subtracting the mean RTs to the congruent color words from the mean RTs to the incongruent color words. Food interference scores were calculated by the mean RTs to the control words subtracted from the mean RTs to the food-related ones. Life goals interference scores were calculated by subtracting the mean RTs to the goal-related words from the mean RTs to the control words. Salivating was calculated by subtracting the weight of saliva for the control stimuli from the weight of saliva for the food-related stimuli.

Figure 1. Flow of participants in Study 2



*Figure 2.* The first series of stimuli consisted of images of the high calorie or low calorie foods or beverages were presented in a colored background.



*Figure 3.* The first series of stimuli consisted of images of the high calorie or low calorie foods or beverages were presented in a colored background.



*Figure 4.* The third series of stimuli consisted of two stimuli from series two (high calorie and low calorie images).

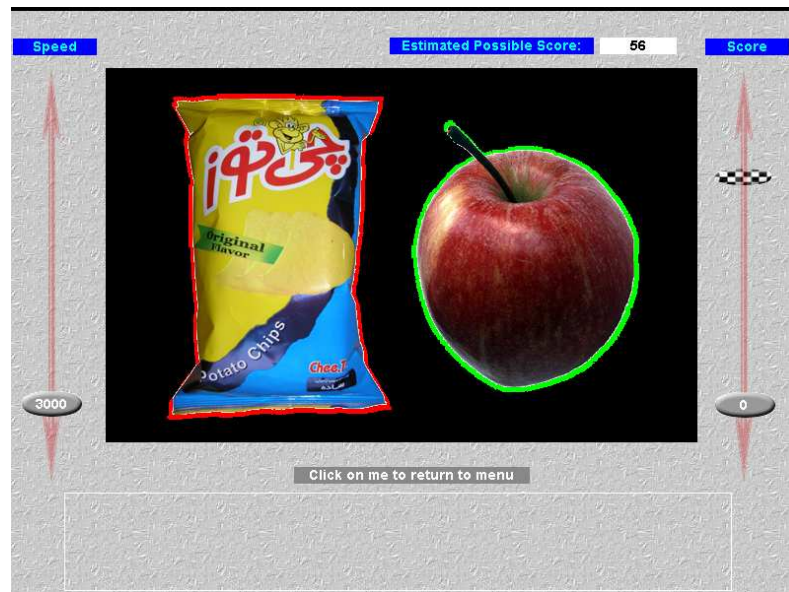
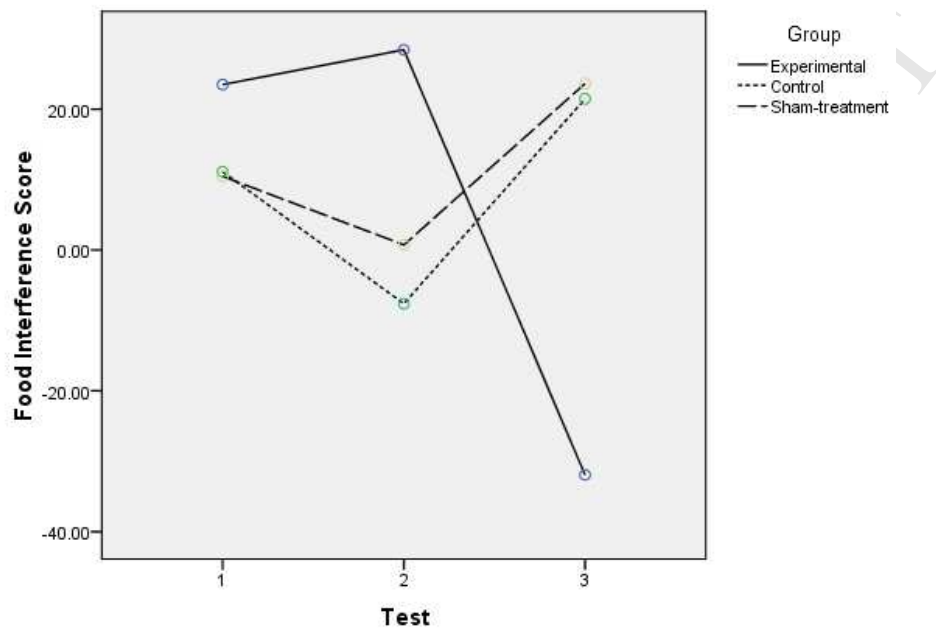


Figure 5. Food interference score changes across the groups from pretest (Test 1) to posttest (Test 2) to follow-up (Test 3).



Note. Changes in the interference score were significant from pre-test to the follow-up assessment.